Nº 9792 A.D. 1900

Date of Application, 28th May., 1900

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PROVISIONAL SPECIFICATION.

"Improvements in and relating to Screw Propellers".

I, The Honourable CHARLES ALGERNON PARSONS, Engineer, of Heaton Works, Newcastle-on-Tyne, in the County of Northumberland, do hereby declare the nature of this invention to be as follows:—

My invention relates to screw propellers for fast ships, and especially to those for use where the shaft rotates at high angular velocity. I find by experiment that cavitation arises principally in two places: (1) at the back faces of the blades near the tips; (2) around the cone abaft the propeller.

The object of my invention is to remove or reduce such cavitation.

It has been established by experiment, by Dynes and others, that the normal pressure on a plane, moved at small inclinations through air or water, varies approximately as the angle of inclination, and the square of velocity of motion.

In a screw propeller of usual pitch ratio, say from 1 to 1.5 pitch co-efficient, the angle of inclination of the blade to the direction of motion through the water is approximately the same for such distances from the shaft line as lie outside two-fifths the radius of the propeller, while the velocity at these points through the water varies approximately as the distance from the shaft. From this it follows that the pressure upon the water of any element of the blades (between the above limits) will vary approximately as the square of the distance of the element from the shaft line. In high speed vessels, when the water pressures are great, cavitation first commences near the tips of the blades (as I have proved experimentally) and extends towards the roots of the blades as the speed or slip ratio of the propeller is increased.

The first part of my invention consists in reducing the cavitation which takes place at the back faces of the propeller blades near their tips by forming the blades with a reduced pitch near their tips.

Where the pitch of the blades has been thus reduced towards the tips, I have found by experiment that cavitation is much reduced, and the efficiency is improved. Theoretically it would appear that this variation should be such that the slip ratio at any given distance from the shaft should be inverse in proportion to the square of that distance, and that with such a propeller of graduated pitch ratio, under these conditions, cavitation would commence over a large area of the blades simultaneously, and that a greater mean slip ratio and thrust would be permissible, without producing cavitation. This conclusion I have confirmed by experiment.

In carrying this part of my invention into effect, according to one modification, I therefore form such fast running propellers with a reducing pitch, the reduction commencing at about one half to two-thirds outwards from the boss or blade root, and increasing to about a 10 *per cent.* reduction of pitch at the blade tips.

The second part of my invention relates to the cavitation which, alluded to above, is found to take place around the cone abaft the propeller. This cavitation is due to the rotational velocity imparted to the water in the vicinity of the boss, by the normal action of the blades, and also their skin and eddy friction in the water, which rotational velocity increases rapidly as the water tends to close in around the after cone on the principle in hydro-dynamics, that the angular momentum tends to remain constant in a vortex. The angular velocity of the water around the cone is therefore much in excess of that of the propeller cone itself.

[*Price* 8d.]

The second part of my invention consists in providing small vanes on the propeller cone, adapted to prevent cavitation around the cone, and to utilize for propulsion some of the rotational energy of the water close to the propeller cone, which is lost with the type of propellers in ordinary use.

In carrying this part of my invention into effect, according to one modification, I provide small vanes on the cone similar to the feathers in an arrow. These vanes may be parallel to the shaft or set at a moderate angle thereto, with a pitch of the same or opposite hand to that of the propeller itself. In my experiments I have found that when three such vanes are provided on the after cone set parallel to the shaft, and having their outer edges practically parallel to the centre line of the shaft, they largely reduce or entirely prevent cavitation round the after cone. The advantages of the vanes are two-fold: (1) some of the angular momentum of the water that would otherwise be lost is imparted through the vanes to the shaft and assists its rotation; (2) the angular velocity of the column being much diminished, the water closes in more easily, and presses on the cone abaft the propeller boss, thus imparting an additional forward thrust to the shaft.

Dated this 28th day of May, 1900.

MARKS & CLERK
18, Southampton Buildings, London, W.C.
13, Temple Street, Birmingham, and
25, Cross Street, Manchester, Agents.

COMPLETE SPECIFICATION.

Improvements in and relating to Screw Propellers

I, The Honourable CHARLES ALGERNON PARSONS, Engineer, of Heaton Works, Newcastle-on-Tyne, in the County of Northumberland, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

My invention relates to screw propellers for fast ships, especially to those for use where the shaft revolves with high angular velocity. I find by experiment that the cavitation which attends high speed propellers arises principally in two places, namely, at the back faces of the blades near the tips, and around the conical tip of the propeller boss behind the blades.

The object of my invention is to remove or reduce such cavitation.

According to the experiments of Dines and others, it has been established that the normal pressure on a plane moved at small inclinations through air or water, varies approximately as the angle of inclination and the square of the velocity of motion. Now in a screw propeller of the usual pitch ratio, say from 1 to 1.5 pitch co-efficient, the angle of inclination of the blade to the direction of motion through the water is approximately the same for such distances from the shaft line as lie outside about two fifths of the radius of the propeller circle; while the velocity of these points through the water varies approximately as the distance from the shaft. From this it follows that the pressure upon the water of any element of the blades (between the above limits) will vary approximately as the square of the distance of the element from the shaft line. In high speed vessels, when the water pressures are great, cavitation first commences near the tips of the blades (as I have proved experimentally), and extends towards the roots of the blades as the speed or slip ratio of the propeller is increased.

The cavitation which is found to take place around the conical end of the boss abaft the propeller is due to the rotational velocity imparted to the water in the vicinity of the boss, by the normal action of the blades and also by their skin and eddy friction on the water, which rotational velocity increases rapidly

as the water tends to close in around the after cone, following the principle in hydrodynamics that the angular momentum in a vortex tends to remain constant. The angular velocity of the water around the cone is therefore much in excess of that of the propeller cone itself.

My invention consists firstly in reducing the cavitation which takes place at the back faces of the propeller blades near the tips by forming the blades with a reduced pitch near their tips.

The second part of my invention consists in providing small vanes on the propeller cone adapted to prevent cavitation around the cone, and to utilise for propulsion some of the rotational energy of the water close to the propeller cone which is lost with the type of propellers in ordinary use.

To obtain a high mean slip ratio and thrust, without producing serious cavitation has been the object of many inventors, but their efforts to effect this end have hitherto been made among other things in the direction of increasing the pitch of the blades towards their points. I have ascertained that the desired effect is produced by forming fast running propellers with a reducing pitch towards their tips the reduction commencing about one half to two thirds outwards from the boss of blade root; such reduction of pitch increasing to about a ten *per cent.* reduction at the blade tips.

Theoretically also it would appear—first:—that this variation of pitch should be such that the slip ratio at any given distance from the shaft, should be in inverse proportion to the square of that distance; second: that cavitation would commence simultaneously over a large area of propeller blade, thus constructed; third:—that such propellers could be run faster without producing cavitation, while at the same time effecting a greater mean slip ratio and thrust than would be possible with propellers constructed with blades of constant or increasing pitch towards their points. I have confirmed this by experiments on propellers constructed according to my invention which is based on this theory.

In order to clearly explain the difference between an ordinary propeller and one constructed according to my invention, I have appended two sheets of drawings in which,

Figures 1 and 2 are elevation and plan, respectively, of an ordinary propeller, the latter view shewing blade sections *a, b, c, d, e,* and *f* on the lines A. A. B. B. C. C. D. D. E. E. and F. F. respectively, of Figure 1. A diagram of the pitch variation of this propeller is also shewn in Figure 2.

Figures 3 and 4 are elevation and plan respectively, of my new construction of propeller with reduced pitch; the plan shewing blade sections *g, h, j, k, m* and *n,* on the lines G. G. H. H. J. J. K. K. M. M. and N. N., respectively of Figure 3. A diagram of the pitch variation of my propeller is also shewn in Figure 4, for comparison with that shewn in Figure 2.

Figures 5 and 6 are elevation and plan of a propeller provided with vanes.

Figure 7 is a section through A, A. of Figure 5 drawn to an enlarged scale.

The first part of my invention is illustrated by Figures 1 to 4 inclusive.

In the propellers illustrated in Figures 1 and 2, the angle of inclination of the blade from section *c c* outward to the tip of the blade is approximately constant; while the pitch of the blade increases continuously from *c c* out to the tip, but is constant from *c c* inward to the root section *f f*. A diagram representing the pitch variation of the propeller seen in Figure 2 may be obtained in this manner:—Along the horizontal axis of the propeller from its intersection with the vertical blade axis, set off a distance *p* equal to one fourth of the pitch of the blade at the root section *f f*, and erect here a perpendicular line. Set off along this perpendicular line a distance P^1, equal to the radius of the root section *f. f*. Now, since the pitch of the blade does not vary at the three sections *e e*, *d d* and *c c*, distances P. 2., P. 3., and P. 4., corresponding respectively to the radii of these sections, may be set off along this perpendicular line. The pitch of the blade increases, however, from section *c c* outward: set off, therefore, distances *q* and *r* to represent one fourth of the pitch of the sections *b b*

and *a a* respectively. Erect perpendiculars Q^6 and R^6, their lengths corresponding respectively to the radii of sections *b b* and *a a*; then a curve drawn through the points 1, 2, 3, 4, 5 and 6 will represent the pitch variations of the propeller blade; while a line from each point drawn to the intersection of the horizontal and vertical axes of the propeller gives the major axis and consequently the inclination of each blade section. It will be observed that sections *a a* and *b b* have the same inclination to the direction of motion as each other, and that the inclination of section *c c* varies very little from them.

Referring now to the propeller constructed according to my invention, and illustrated in Figures 3 and 4, the pitch of the blade is constant from the root section *n n* outward to a point about midway between the sections *k k* and *j j*, but it decreases from this point outward to the tip of the blade.

The line of pitch variation for this propeller may be obtained in the same manner as in the case just described. Let the distance *w* from the vertical axis of the blade represent one fourth of the pitch of the three sections *n, n m m*, and *k k*; and distances *u, t* and *s* represent one fourth of the pitch at sections *j j*, *h h* and *g g* respectively. By erecting perpendicular lines from the horizontal axis at these distances, and setting off lengths thereon corresponding to the radii of the various sections, points 7, 8, 9, 10, 11 and 12 are obtained; and the line passing through them represents the pitch variation of my propeller. As is also the case in Figure 2, a line drawn from these points to the intersection of the horizontal and vertical axes of the propeller gives the inclination of the various blade sections to the direction of motion. I have found that propellers constructed as just described with reference to Figures 3 and 4 can be run at a higher speed without the production of cavitation and with a higher mean slip ratio and thrust than has hitherto been possible.

In carrying the second part of my invention into effect as illustrated by Figures 5, 6 and 7, I provide small vanes *v, v* on the cone *x* of the propeller shaft *y*, which vanes may be parallel to the shaft as shewn, or set at a moderate angle thereto, with a pitch of the same or opposite hand to the propeller itself. In my experiments I have found that when three vanes are provided on the cone, and set parallel to the shaft as illustrated, with their outer edges practically parallel to the centre line of the shaft, the cavitation produced round the cone *x* at a given speed is largely reduced, or entirely prevented. As hereinbefore explained, the angular velocity of the water around the cone is much in excess of that of the propeller cone itself, but vanes such as those just described retard the water vortex around the cone, with two beneficial results; firstly, some of the angular momentum of the water vortex that would other-wise be lost, is imparted to the vanes and consequently assists in rotating the shaft; and secondly, owing to the diminution of the angular velocity of the water round the shaft, the water more easily closes in and presses on the cone abaft the propeller boss, thus imparting an additional forward thrust to the shaft.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:

1. A screw propeller provided with blades constructed with a reduced pitch towards their tips the reduction commencing from about one half to two thirds outward from the blade roots, substantially as described.
2. A screw propeller fitted with vanes behind the blades as set forth.

Dated this 17th day of January 1901.

MARKS & CLERK
18, Southampton Buildings, London, W.C.
13, Temple Street, Birmingham, and
25, Cross Street, Manchester. Agents.

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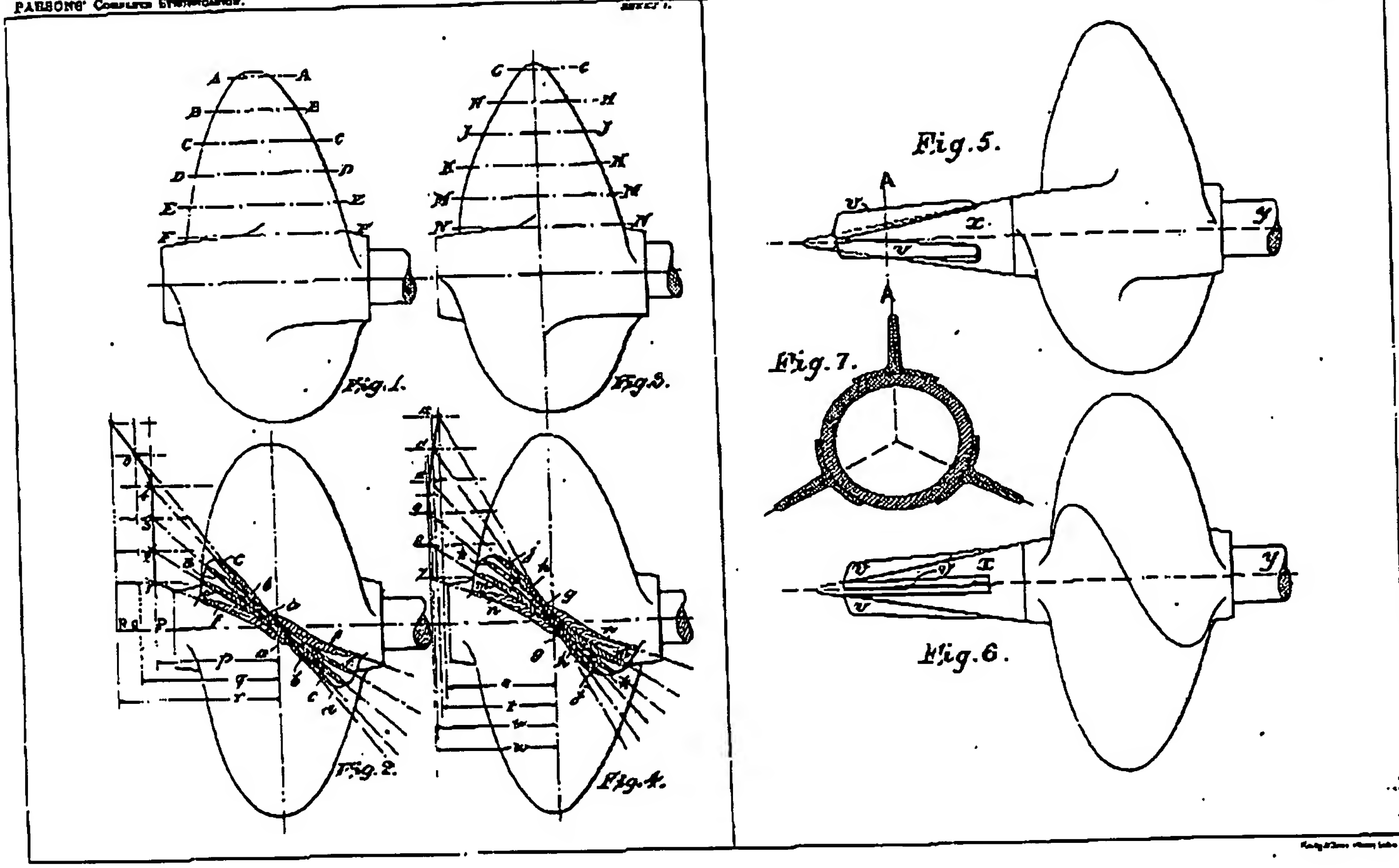
A.D. 1900, May 18. N° 9703.
PARSONS' COMPLETE SPECIFICATION.



[This drawing is a reproduction of the Original on a reduced scale]

A.D. 1900. MAY 28. N° 9792.
PARSONS' COMPLETE SPECIFICATION.

SHEET 1.

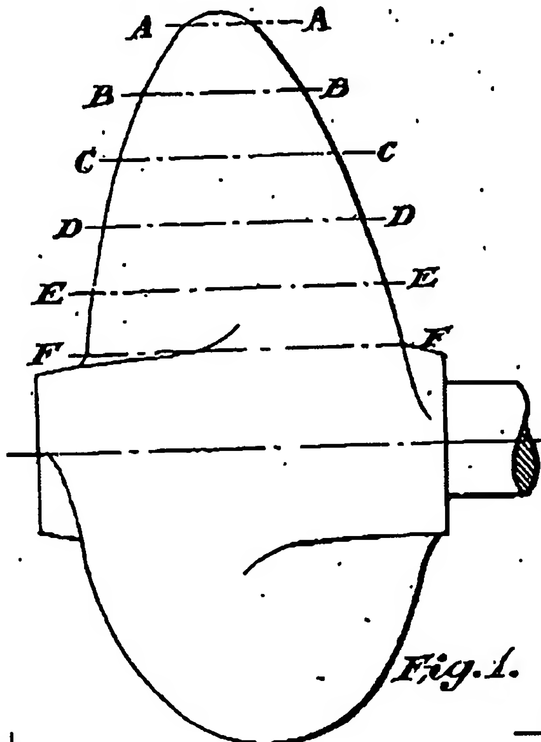


Fig. 1.

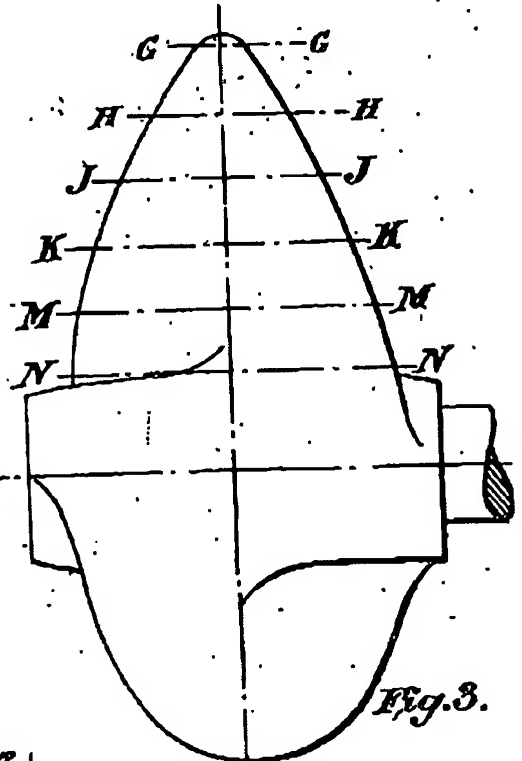


Fig. 3.

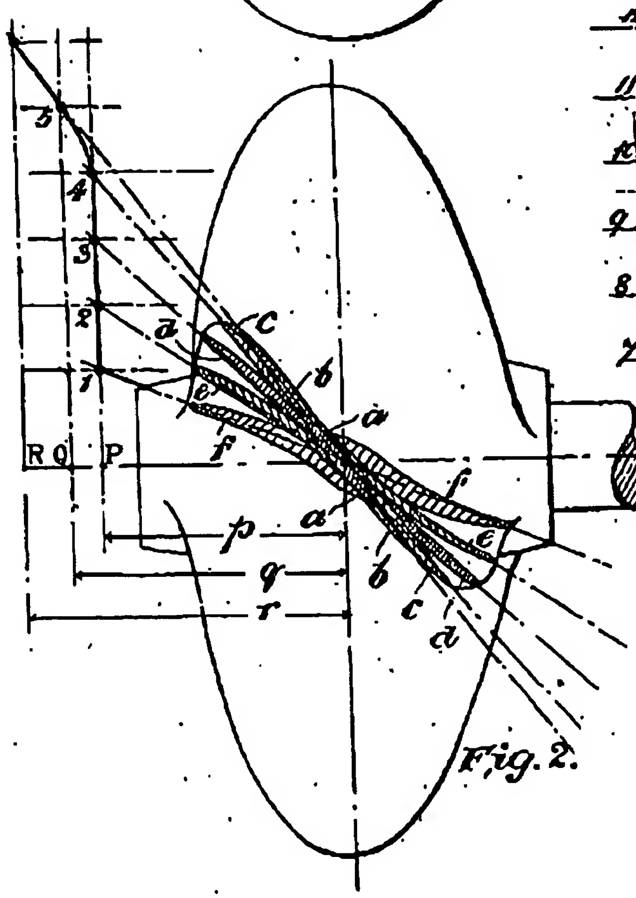


Fig. 2.

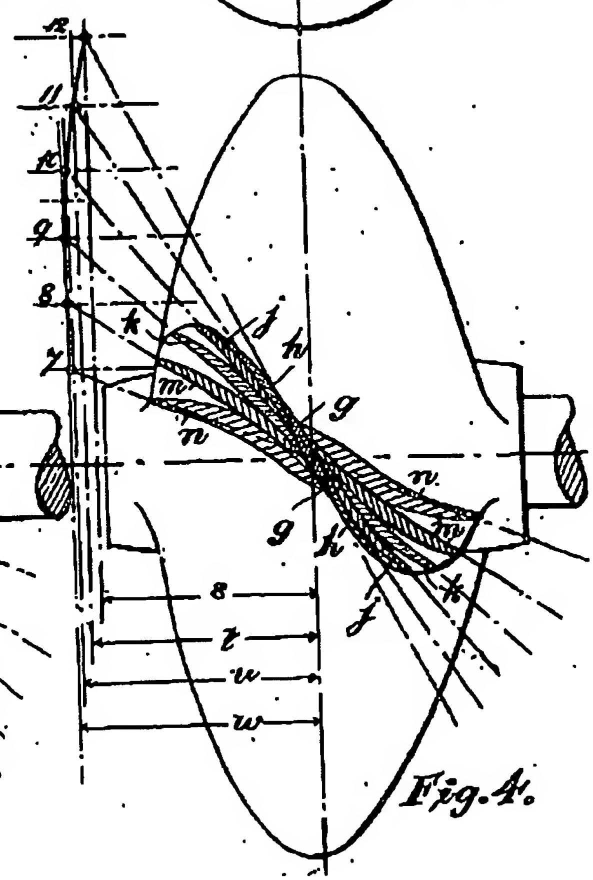


Fig. 4.

(2 SHEETS)
SHEET 2.

Fig. 5.

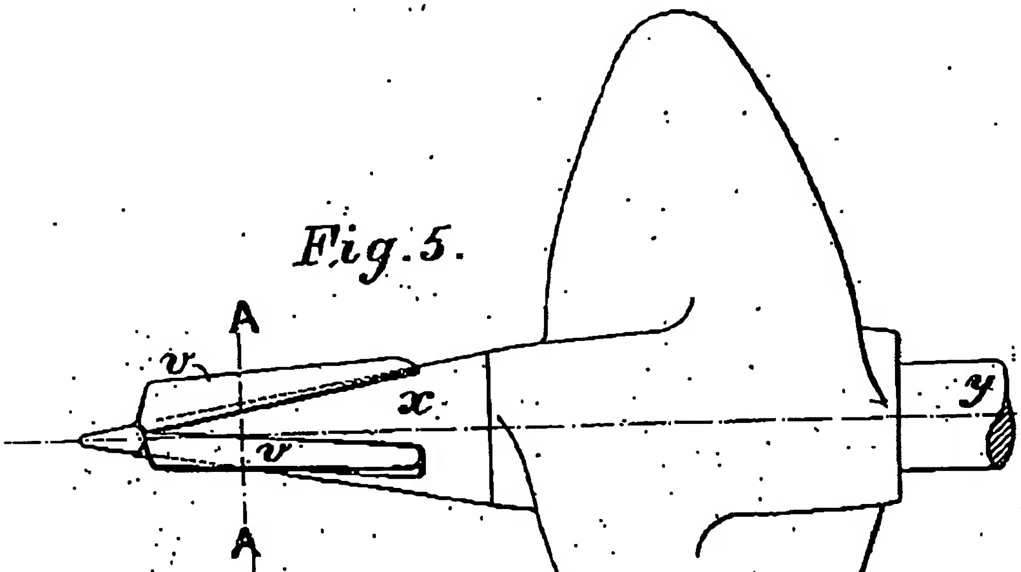
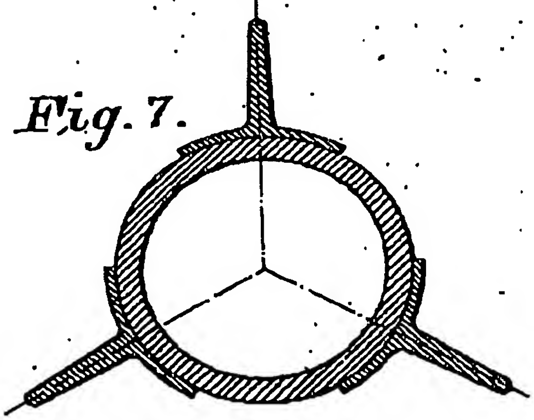


Fig. 7.



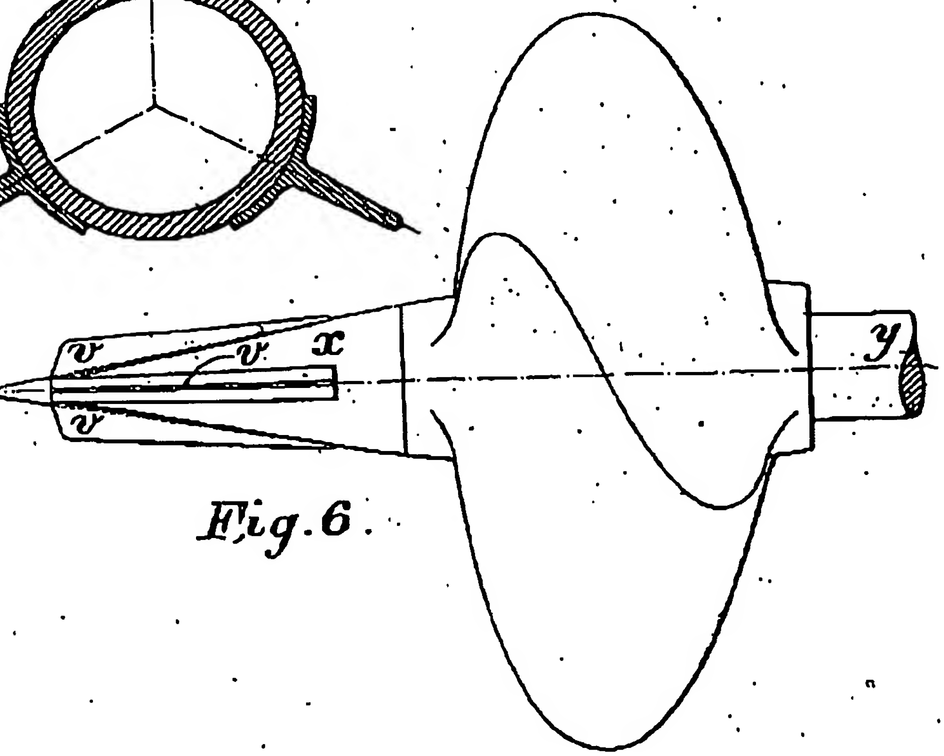


Fig. 6.

[This Drawing is a reproduction of the Original on a reduced scale.]

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